Table S1. Characteristics of five budgets from four countries practiced on farm level.

	Romania DOE – optimum economic fertilizer doses	**The Netherlands ANCA - Annual Nutrient Cycling Assessment**	**Germany DüV – (Fertilization Ordinance)**	**Germany StoffBilV - (Ordinance on farm gate budget)**	**Switzerland Suisse-Balance**
Overarching goals of budget	Implementing the Code of Good Agricultural Practices for water protection against pollution with nitrates from agricultural sources and the Action Program	to demonstrate that milk is produced sustainably; increase production efficiency of milk; prerequisite to change legal nutrient accounting from generic to farm specific, e.g., excretion and fertilization standards	implementation of Nitrates Directive, definition of good agricultural practice; reduction of risk of N losses; prerequisite for subsidies	forcing farmers towards a more efficient and sustainable manure use; transparency of nutrient flows of farms	proof of a balanced nitrogen and phosphorus budget, according to current legislation; overview over nutrient status of farm/operational units of farm; determine acceptable animal density for farm
Implemented	since 2016	since 2016	since 2007	since 2018	since 2002
How binding for the farmers?	legally binding; prerequisite for subsidies	benchmarking among dairy farmers	legally binding until March 2020; prerequisite for subsidies	legally binding	legally binding; prerequisite for subsidies
Control mechanisms	control agencies of payments for interventions in agriculture; once in a year a sample of farmers (5% of farms) is controlled	no control, but intensive farm advice	control agencies of Federal States;	control agencies of Federal States; record keeping and retention requirement; a few farms are controlled, no common rules	control is up to Swiss cantons; no guideline on a unified implementation and execution; ca. 45 % of all farms controlled yearly
Sanctions	CC: sanctions triple in case of repetition of offence, up to cancellation of all subsidies	no legal sanctions, but dairy industry refuses milk	CC: sanctions triple in case of repetition of offence, up to cancellation of all subsidies (at least 1 % of all farms receiving		reduced subsidies up to cancellation of all subsidies, if nutrient surplus is repeatedly too high [33]

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			subsidies show offences against fertilization ordinance and CC[1)]); Fertilization ordinance: duty to attend courses on fertilization, in case of repeated non-compliance legal fines of up to 50,000 €		
Who is required to calculate the budget?	all farmers who want to apply higher quantities of fertilizers than the maximum standards from the Code of Good Agricultural Practices at the farm level	only dairy farmers	all farms, except[2)]	farmers who run farms with > 50 LU;> 30 ha and > 2.5 LU/ha; import of manure; biogas plants processing imported manure	all farms except those without import of fertilizers containing N and P, if the LU/ha are kept according to certain zone-related standards[3)]
What is determined?	the nutrient balance within the farm/parcel level and the economic optimum fertilizers doses	N- and P-efficiency, in % and as N-surplus (on farm level, in detail for the herd, manure, soil and crop)	N- and P-efficiency, as N- and P-surplus on farm level, calculated as net soil surface budget	N- and P-efficiency, as N- and P-surplus on farm level, calculated as gross farm budget	balancing N- and P-supply by fertilizers with N- and P-requirements by crops based on standardized fertilization guidelines
Underlying N-application standard	170 kg/ha applied to ground (manure and organic fertilizer)	250/230 kg N/ha with derogation (manure)	170 kg/ha applied to ground (manure and organic fertilizer)	not applicable	depending on crop
Data management	There is a calculation tool in the form of a workbook sheet	central database: 90 % by third parties (authoriza-	Different calculation tools available, on federal state level	Different calculation tools available (module of DüV-tool), on federal state level	Different calculation tools available; central database on transfer of manure and

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		tion), e.g., labs (soil samples, silage samples), feed companies, milk processor; 10 % by farmer (farm advisor)			organic (recycling) fertilizers (HODUFLU); supplier and customer both have to verify details on delivery
Inflow					
Feedstuff	x	x	only roughages: calculated from standard data	x	x, including proofs of nutrient reduced feeds
Commercial fertilizer	x	x	x	x	x
Manure	calculated from standard data on excretions		calculated from standard data on excretions	x, manure/excretion only if imported to farm	calculated from excretion of animals plus imported manure
Seeds, planting material	x		x	x	
Animals	x	x		x	
Leguminous N -fixation	x	x	x	x	
Others	type of grassland/arable land; soil type	type of grassland/arable land; soil type; stock change			type of grassland/arable land; straw import; feedstuff import
Removal					
Animal products	x	x; milk (quantity and quality: fat, protein, urea)		x	

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Manure	(x), manure/excretion only if removed from farm	x	x	x, manure/excretion only if removed from farm	x
Feedstuff	(x), only if removed from farm	(x), only if removed from farm	x, consumption of roughages: calculated by number of animals, grazing hours, plus field, storage and stable losses	(x), only if removed from farm	x, consumption of roughages: calculated by number of animals and intensity of grass production
Arable crops	effective yield	effective yield	effective yield	effective yield	Standard/effective crop yield
Animals	(x), only if removed from farm	characterization of herd		x	
Internal flows					
Feed consumption		x, consumption of roughages: calculated by number of animals, grazing hours	x, consumption of roughages: calculated by number of animals plus field, storage and stable losses		
N and P-excretion		x			
NH_3-emissions		x			
Results					
farm specific excretion rates per animal	no	yes	no	no	yes, based on individual agreement with the canton on nutrients-reduced feeds
farm budget	yes	BIN[4]: 218 kg/ha 2016: 188 kg/ha		175 kg/ha	

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soil surface budget	no	BIN[4]: 158 kg/ha 2016: 133 kg/ha	60 kg/ha; from 2020 onwards: 50 kg/ha		N- and P-surplus ≤ 10 % of the standard nutrient requirement of crop
carbon input to soil	no	x			
greenhouse gas emissions	yes	x			

[1)]Cross Compliance;[2)]farms < 15 ha; cultivation of hops, vegetables, wine and strawberries < 2 ha; cultivation of ornamental crops, Christmas trees, short rotation coppices, nurseries, wine and fruit trees not in production; areas with grazing animals (N excretion < 100 kg/ha); precondition for all farms: no import of manure; [3)]valley zone: 2 LU, equivalent to 210 kg N/ha and 30 kg P/ha; hilly zone: 1.6 LU, equivalent to 168 kg N/ha and 24 kg P/ha; mountain zone I: 1.4 LU, equivalent to 147 kg N/ha and 21 kg P/ha; mountain zone II: 1.1 LU, equivalent to 115.5 kg N/ha and 16.5 kg P/ha; mountain zone III: 0.9 LU, equivalent to 93.6 kg N/ha and 13.5 kg P/ha; mountain zone IV: 0.8 LU, equivalent to 84 kg N/ha and 12 kg P/ha; [4)]benchmark: means of Dutch farm accounting data network (BIN).